well on in his ninety-seventh year. His long-continued and laborious researches in the zoology, palæontology, anthropology, and antiquities of his native land gave him a high place among men of science. Among a host of minor contributions he was the author of a standard work on the Scandinavian fauna; but that by which he was best known to us is the book of which the English translation, edited by Sir John Lubbock, bears the title of "The Primitive Inhabitants of Scandinavia; an Essay on Comparative Ethnography, and a Contribution to the History of the Development of Mankind."

The number of our ordinary members has been fairly kept up, the additions by election having slightly exceeded the losses by death and resignation; but a larger increase in the future will be necessary in order to carry on the operations of the Institute in a successful manner, especially under the new conditions to which I shall have to advert presently. Even by the most careful management our treasurer has not succeeded in bringing the expenditure of the year quite within our ordinary income.

The journal, I am glad to report, has been brought out with exemplary punctuality, under the able and energetic supervision of our director, Mr. Rudler. To this part of our operations I think we may look with unmixed satisfaction, the number, character, and variety of the communications contained in it being quite equal to those of former years.

With regard to our future, the next year will probably be one of the most momentous in our annals, as we have determined upon a great step, no less than a change of domicile. It was ascertained in the course of last summer that we could only remain in our present quarters at an increased rent upon that which we had hitherto paid, and we therefore considered whether it would be possible to obtain as good or better accommodation elsewhere. It happened fortunately that the Zoological Society was about to move into new freehold premises at No. 3, Hanover Square, and would have spare rooms available for the occupation of other societies. A committee of the Council was appointed to examine and report upon the desirability of moving, and negotiations were entered into with the Council of the Zoological Society which have ended in our becoming their tenants for the future. We shall have for the purposes of our library, office, and Council meetings, two convenient rooms on the second floor immediately above the library of the Zoological Society, and for the purpose of storing our stock of publications a small room on the basement. We shall also have the use of a far more handsome and commodious meeting room than that which we occupy at the present moment, and in a situation which is in many respects more advantageous. Let us trust that this change may be the inauguration of an era of prosperity to the Institute, and of increased scientific activity among its members.

THE FORMATION OF SMALL CLEAR SPACES IN DUSTY AIR[1]

In the introduction a few remarks are made on the growing interest in everything connected with dust, whether it be the organic germs floating in the air, or the inorganic particles that pollute our atmosphere. Prof. Tyndall's observations on the dark plane seen over a hot wire[2] are referred to, Lord Rayleigh's recent discovery of the dark plane formed under a cold body[3] is described, and attention called to Dr. Lodge's experiments described in a letter to NATURE, vol. xxviii. p. 297.

The experiments described in this paper were made in a small dust-box, blackened inside, glazed in front, and provided with a window at one side. For illumination two jets of gas inclosed in a dark lantern were used. The light entered the dust-box by the side window and could be condensed on any part of the inside of the box, by means of two lenses fixed in a short tube, and loosely attached to the front of the lantern. Magnifying glasses of different powers were used for observation. The dusts experimented on were made, some of hydrochloric acid and ammonia, some by burning sulphur and adding ammonia, some by burning paper, magnesium, or sodium. Calcined magnesia and lime were also used, as well as ground charcoal. These three last substances were stirred up by means of a jet of air.

[1] Abstract of a paper read to the Royal Society of Edinburgh, January 21, 1884, by Mr. John Aitken.

[2] "Essays on the Floating-Matter in the Air," p. 5. (Longmans, Green, and Co., 1881.)

[3] NATURE, vol. xxviii. p 139.

For testing the effects of slight difference of temperature, tubes in some form or other were generally used. These tubes were closed at the front, projected through the back of the dust-box, and were brought close to the glass front for observation under strong magnifying power. The tubes were heated or cooled by circulating water through them, in a small tube passing through their interior.

Suppose the experiments to be begun by introducing a round tube into its place in the dust-box and then filling the box with any dust, everything being then left for some time so that all the apparatus may acquire the same temperature. If the light be now allowed to fall on the box, and be quickly brought to a focus on the tube, it will be found that the dust is in close contact with it on the top and sides, but *underneath* there will be seen a clear space. Close examination will show the particles to be falling on the upper surface of the tube, and coming into contact with it, while underneath a clear space is formed by the particles falling out of it. If the tube is now slightly cooled, a downward current is formed, and the currents of dustless air from below the tube meet under it, and form a dark plane in the centre of the descending current. It is shown that gravitation can, under favourable conditions, produce this separation of the dust quickly enough to keep up a constant supply of dustless air. No increase of effect is produced by a lower temperature. A temperature of -10° C. makes the dark plane thinner, because it increases the rate of the descending current and carries away the purified air more quickly.

A form of apparatus was arranged to get rid of this separating effect of gravitation. It consisted of an extremely thin and flat piece of metal. This test-surface was placed *vertically* in the dust-box. The air in passing over this piece of apparatus was not caused to take up a horizontal movement at any part of its passage. The result was that even with a temperature of -10° C. the dust kept close to its surface, and no dark plane was formed in the descending current. The dark plane in the cold descending current seems, therefore, not to be an effect of temperature, but is the result of the action of gravitation on the particles under the body. A dark plane was, however, observed when working with this flat surface when cooled, but it was not formed in dusty, but in foggy air, and was found to be due to the evaporation of the fog particles when they approached the cold surface.

If a very little heat, instead of cold, is applied to the round tube in the previous experiment, then the dark space under the tube rises and encircles the tube and the two currents of clear air unite over the tube and form the dark plane in the upward current. But in addition to this heat has been found to exert a repelling effect on the dust. This was proved by putting the thin vertical test-surface in the dust-box and heating it, when it was found that the dust was repelled from its surface, and a dark plane formed in the ascending current, neither of which effects was obtained with cold. The dust begins to be repelled with the slightest rise of temperature, and the dark space in front of the test-surface becomes thicker as the temperature rises. An experiment is then described in which air flowing up between two parallel glass plates is caused to pass from side to side of the channel by the repelling action of heat at different points.

For testing the effects of higher temperatures a platinum wire heated by means of a battery was used. The platinum wire was bent into a U-shape, the two legs being brought close together. This wire was fixed in the dust-box with the bend to the front, and the legs in the same horizontal plane, the two copper wires to which it was attached being carried backwards and out of the box. By this arrangement a clear view was obtained all round the wire, and other advantages secured. Experimenting with this apparatus it was found that every kind of dust had a different sized dark plane. With magnesia and other indestructible dusts it was very thin, with the sulphate dust it was much thicker, and with the sal-ammoniac dust thicker still. So thick was it with the two latter kinds of dust that the dark planes over the two legs expanded and formed one plane. As the particles could be seen streaming into the dark space under the wires, it was obvious that these large dark planes were not caused by repulsion, but by the evaporation or by the disintegration of the dust particles. When making the experiment in a mixture of different kinds of dusts, the hot wire was surrounded by a series of zones of different brightness, and having sharp outlines. The size of the different zones was determined by the temperature necessary to evaporate the different kinds of dust present, and

outside these zones was another, caused by the evaporation of the water from the particles.

The conclusions arrived at from these experiments are that the downward dark plane is produced by this separating action of gravitation, in the space under the cold body, and that the upward dark plane is produced (1) by the separating action of gravitation, (2) by the repulsion due to heat, (3) by evaporation, and (4) by disintegration.

The effect of centrifugal force is considered. It is pointed out that as the air, in its passage over a body such as a tube, curves as much in one direction as it does in another, therefore any centrifugal effect produced in the one part will be reversed in the other. An experiment is described in which an air current is caused to curve through 180° in its passage round the edge of a thin plate, and without any curving in the opposite direction, but no decided centrifugal action could be detected.

The motions of the dust particles produced by the repulsion of the hot surface suggested that electricity might play some part in these phenomena. Experiments were made to test this. The hot body was insulated and connected with an electroscope; but no electrical disturbance was observed, nor could any electrification be got from the dust and hot air streaming up from the hot wires. The effects of electrification were studied by insulating and charging the hot surface. The effect was found to be the opposite of the heat effect. If the potential is slight, and the temperature high, the heat is able to keep the dust off the surface of the body and the dark plane district, but if the temperature falls, or the potential is increased, a point is reached when the electrical attraction overcomes the heat effect, and the dust particles break in upon and destroy the dark space.

It was observed that after the dust particles were electrified they tended to deposit themselves on any surface near them, and experiments were made to determine the best conditions for purifying air in this manner. It was found to be best done by causing as rapid a discharge of electricity as possible, by means of points, surfaces being placed near them to increase the electrification of the dust, and to augment the rate of the currents of air which were driven from the points. These surfaces became places on which the dust deposited itself before losing its charge. A large flask was found to be rapidly cleared of a cloud of dust by means of a point—the dust being almost entirely deposited on the inside surface of the flask. If the end of the conductor in the flask terminated in a sphere, but little effect was produced. Electricity has also been found capable of depositing the very fine dust of the atmosphere. The air in a large flask was purified much more quickly by means of the electric discharge than it could have been by means of an air-pump and cotton-wool filter.

It is shown that a wet and hot surface repels dust more than twice as strongly as a hot dry one. From this it is concluded that the heat and moisture in our lungs exert a protecting influence on the surface of the bronchial tubes and tend to keep the dust in the air which is ebbing and flowing through them from coming into contact with their surfaces. This was illustrated by placing a hot and wet surface in a current of dense smoke, where it remained some time without receiving a speck of soot, while a similar surface, but cold, was blackened with the smoke. It is pointed out that on account of the irregularities on the surface of the tubes, and of the more violent movements of the air in the lungs, and on account of curves and projecting edges, the protection in the lungs is not perfect. Still it is thought that this repelling action at these surfaces must have some influence, and it seems possible it may explain some climatic effects, as it is evident that the lungs will be much better protected in such places as Davos Platz, where the air is cold and dry, and the repelling forces at a maximum, than at places like Madeira, where the air is warm and moist and these forces are at a minimum. This point can, however, only be determined satisfactorily by anatomical examinations of lungs which have lived under the different conditions.

In the experiments it was observed that dust not only tended to move away from hot surfaces, but also that it was attracted by cold ones, and attached itself to them. To study this effect glass plates were put in different positions near the hot platinum wire. Very beautiful impressions of the dark plane can be obtained by placing a piece of glass vertically and transversely over the hot wire. The hot air in flowing over the glass, deposits its dust on the surface of the plate leaving a clear line in the middle, indicating where the dustless air of the dark plane had passed. In this way the dust is trapped on the glass to which it adheres with some firmness, and not only the impressions but the dark planes themselves may thus be preserved.[1]

Other experiments to study the repulsion and attraction of hot and cold surfaces were made by placing glass plates on both sides of the hot wire. An interesting result was obtained when the plates were about 1 mm. apart. Using magnesia powder, the particles could be seen rising in the current, and approaching the hot wire; they were then observed to be violently repelled towards the cold surface, to which they adhered. If there was sufficient difference of temperature, not a single particle of dust was carried by the current past the hot wire.

A thermic filter is then described. In this filter the air is passed through the space formed between two concentric tubes. One tube is kept cold by a stream of water, and the other heated by means of steam or a flame. This instrument was shown in action; one end of the filter was connected with a glass flask, in which the condition of the air was tested. So long as the difference of temperature was kept up, and the current not too rapid, the air passing through it showed no signs of producing cloudy condensation on the pressure being reduced, showing that the filter had trapped all, even the invisible dust particles.

Some experiments on the effect of diffusion on the distribution of dust at the surface of a diaphragm are described. When carbonic acid diffuses into a space, the dust comes close to the diffusing surface, but if hydrogen is the diffusing gas, a clear space is formed in front of the diaphragm.

An explanation is then offered of the repulsion of dust by hot surfaces and its attraction by cold ones. It seems possible, that the dust might be repelled in the same way as the vanes of a Crookes' radiometer, by a radiation effect. That this was not the true explanation was, however, proved by placing in the dust-box a polished silver flat test-surface, one half of which was coated with lamp-black, when it was found that the dark space in front of the lamp-black was not any thicker than that in front of the polished metal. It is thought that the repulsion is due to the diffusion of the hot and cold air molecules. The hot surface repels because the outward diffusing molecules are hot, and have greater kinetic energy than the inward moving ones; and as the side of the dust particle next the hot surface is bombarded by a larger number of hot molecules than the other side, it is driven away from the hot surface. The attraction of a cold surface is explained by the less kinetic energy of the outward than of the inward diffusing molecules. Some experiments are referred to, to show that the rate at which gas molecules diffuse indicate that this diffusion effect is sufficient to account for the repulsion and attraction of the dust.

If the explanation here given is correct, then the dust is repelled in the same way as a vane of a radiometer when placed in front of a surface fixed inside the radiometer bulb, and hotter than the residual gas, the principal part of the energy producing the motion being transferred from the hot surface to the repelled surface by the kinetic energy of the molecules, and not by radiation.

In illustration of the tendency of dust to move from hot and to deposit itself on cold surfaces, the following experiments were made. Two mirrors, one hot and the other cold, fixed face to face and close to each other, were placed in a vessel filled with a dense cloud of magnesia, made by burning magnesium wire. After a short time the mirrors were taken out and examined. The hot one was quite clean, while the cold one was white with magnesia dust. In another experiment a cold metal rod was dipped into some hot magnesia powder; when taken out it had a club-shaped mass of magnesia adhering to its end, while a hot rod attracted none.

This tendency of dust to leave hot surfaces and attach itself to cold ones explains a number of familiar things, among others it tells us why the walls and furniture of a stove-heated room are always dirtier than those of a fire-warmed one. In the one case the air is warmer than the surfaces, and in the other the surfaces are warmer than the air. This effect of temperature is even necessary to explain why so much soot collects in a chimney. It explains something of the peculiar liquid-like movements of hot powders, and perhaps something of the spheroidal condition.

For practical applications, it is suggested that this effect of temperature might be made available in many chemical works for the condensation of fumes, and that it might also be used

[1] Specimens of these trapped dark planes were shown at the meeting, some of them made of white powder deposited on blackened glass, others of charcoal deposited on opal glass.

for trapping soot in chimneys. A small trap of this kind was shown. It consisted of a tall metal tube or chimney, surrounded by another tube slightly larger. The products of combustion are taken up the centre tube and down the intervening space. The heat of the gases is thus made to do its own filtering. This apparatus being placed over a smoky lamp, it trapped out most of the soot, and deposited it on the inside of the outer tube. This arrangement of apparatus is too delicate and troublesome for general use, and it is suggested that, as by simply cooling gases in presence of plenty of surface much of its dust is deposited, it might be possible and advantageous under certain conditions to purify air by heating and cooling it a number of times, which could be done at a small expense by means of regenerators.

Experiments were also made by discharging electricity into the smoke in a chimney. This also produced a marked diminution in the blackness of the escaping smoke. The supply of electricity of sufficiently high potential is however a difficulty for the present.

A VAST DUST ENVELOPE[1]

SCIENTIFIC men have evinced extraordinary interest in the wonderfully brilliant sunsets that have for some time past been observed in different parts of the world. Various theories have been advanced, but all are agreed that the real cause is not yet definitely determined.. At the Brevoort House yesterday, a *Tribune* reporter spent a couple of hours with Prof. S. P. Langley, astronomer at Allegheny Observatory, Allegheny, Penn. His views upon the topic of the transmissibility of light through our atmosphere are stated below :

"At first I supposed the sunset matter a local phenomenon, but when the reports showed it to have been visible all over the world, it was obvious that we must look for some equally general cause. We know but two likely ones, and these have been already brought forward. One is the advent of an unusual amount of meteoric dust. While something over ten millions of meteorites are known to enter our atmosphere daily, which are dissipated in dust and vapour in the upper atmosphere, the total mass of these is small as compared with the bulk of the atmosphere itself, although absolutely large. It is difficult to state with precision what this amount is. But several lines of evidence lead us to think it is approximately not greatly less than 100 tons per diem, nor greatly more than 1,000 tons per diem. Taking the largest estimate as still below the truth, we must suppose an enormously greater accession than this to supply quantity sufficient to produce the phenomenon in question; and it is hardly possible to imagine such a meteoric inflow unaccompanied with visual phenomena in the form of 'shooting stars,' which would make its advent visible to all. Admitting, then, the possibility of meteoric influence, we must consider it to be nevertheless extremely improbable.

"There is another cause, which I understand has been suggested by Mr. Lockyer—though I have not seen his article—which seems to be more acceptable—that of volcanic dust; and in relation to this presence of dust in the entire atmosphere of the planet, I can offer some little personal experience. In 1878 I was on the upper slopes of Mount Etna, in the volcanic wastes, three or four hours' journey above the zone of fertile ground. I passed a portion of the winter at that elevation engaged in studying the transparency of the earth's atmosphere. I was much impressed by the fact that here, on a site where the air is supposed to be as clear as anywhere in the world, at this considerable altitude, and where we were surrounded by snow-fields and deserts of black lava, the telescope showed that the air was filled with minute dust particles, which evidently had no relation to the local surroundings, but apparently formed a portion of an envelope common to the whole earth. I was confirmed in this opinion by my recollection that Prof. Piazzi Smyth, on the Peak of Teneriffe, in mid-ocean, saw these strata of dust rising to the height of over a mile, reaching out to the horizon in every direction, and so dense that they frequently hid a neighbouring island mountain, whose peak rose above them, as though out of an upper sea. In 1881 I was on Mount Whitney, in Southern California, the highest peak in the United States, unless some of the Alaskan mountains can rival it. I had gone there with an expedition from the Allegheny Observatory, under the official direction of General Hazen, of the Signal Service, and had camped at an altitude of 12,000 feet, with a special object of studying analogous phenomena. On ascending the peak of Whitney, from an altitude of nearly 15,000 feet the eye looks to the east over one of the most barren regions in the world. Immediately at the foot of the mountain is the Inyo Desert, and on the east a range of mountains parallel to the Sierra Nevada, but only about 10,000 feet in height. From the valley the atmosphere had appeared beautifully clear. But from this aërial height we looked down on what seemed a kind of level dust-ocean, invisible from below, but whose depth was six or seven thousand feet, as the upper portion only of the opposite mountain range rose clearly out of it. The colour of the light reflected to us from this dust-ocean was clearly red, and it stretched as far as the eye could reach in every direction, although there was no special wind or local cause for it. It was evidently like the dust seen in mid-ocean from the Peak of Teneriffe—something present all the time, and a permanent ingredient in the earth's atmosphere.

"At our own great elevation the sky was of a remarkably deep violet, and it seemed at first as if no dust was present in this upper air, but in getting, just at noon, in the edge of the shadow of a range of cliffs which rose 1,200 feet above us, the sky immediately about the sun took on a whitish hue. On scrutinising this through the telescope it was found to be due to myriads of the minutest dust particles. I was here at a far greater height than the summit of Etna, with nothing around me except granite and snow-fields, and the presence of this dust in a comparatively calm air much impressed me. I mentioned it to Mr. Clarence King, then Director of the United States Geological Surveys, who was one of the first to ascend Mount Whitney, and he informed me that this upper dust was probably due to the 'loess' of China, having been borne across the Pacific and a quarter of the way around the world. We were at the summit of the continent, and the air which swept by us was unmingled with that of the lower regions of the earth's surface. Even at this great altitude the dust was perpetually present in the air, and I became confirmed in the opinion that there is a permanent dust shell inclosing the whole planet to a height certainly of about three miles (where direct observation has followed it), and not improbably to a height even greater; for we have no reason to suppose that the dust carried up from the earth's surface stops at the height to which we have ascended. The meteorites, which are consumed at an average height of twenty to forty miles, must add somewhat to this. Our observations with special apparatus on Mount Whitney went to show that the red rays are transmitted with greatest facility through our air and rendered it extremely probable that this has a very large share in the colours of a cloudless sky at sunset and sunrise, these colours depending largely upon the average size of the dust particles.

"It is especially worth notice that, as far as such observations go, we have no reason to doubt that the finer dust from the earth's surface is carried up to a surprising altitude. I speak here, not of the grosser dust particles, but of those which are so fine as to be individually invisible, except under favouring circumstances, and which are so minute that they might be an almost unlimited time in settling to the ground, even if the atmosphere were to become perfectly quiet. I have not at hand any data for estimating the amount of dust thrown into the air by such eruptions as those which recently occurred in Java and Alaska. But it is quite certain, if the accounts we have are not exaggerated, that the former alone must have been counted by millions of tons and must in all probability have exceeded in amount that contributed by meteorites during an entire year. Neither must it be supposed that this will at once sink to the surface again. Even the smoke of a conflagration so utterly insignificant, compared with nature's scale, as the burning of Chicago, was, according to Mr. Clarence King, perceived on the Pacific Coast; nor is there any improbability that I can see in supposing that the eruption at Krakatoa may have charged the atmosphere of the whole planet (or at least of a belt encircling it) for months with particles sufficiently large to scatter the rays of red light and partially absorb the others, and to produce the phenomenon that is now exciting so much public interest. We must not conclude that the cause of the phenomenon is certainly known. It is not. But I am inclined to think that there is not only no antecedent improbability that these volcanic eruptions on such an unprecedented scale are the cause, but that they are the most likely cause which we can assign."

[1] From the *New York Daily Tribune*, January 2. Communicated by rof. Piazzi Smyth.